SUBSTITUTE SPECIFICATION

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GAMMA CORRECTION CIRCUIT, DISPLAY PANEL, AND DISPLAY DEVICE INCLUDING SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a gamma correction circuit and a display panel and further relates to a display device, such as a liquid crystal display device, that includes a gamma correction circuit and a display panel.

2. Description of the Related Art

[0002] Generally, a display panel of a display device such as a liquid crystal display device has a nonlinear correlation between an applied voltage and a brightness of a display element, that is, a gamma characteristic. Fig. 5 shows a typical gamma characteristic. Solid curve A in Fig. 5 is a characteristic (that is, a gamma characteristic) of a liquid crystal display element in which a voltage is applied as is without correcting (gamma-correcting) the image voltage (V_1 or V_m, for example). In Fig. 5, the horizontal axis represents the applied voltage and the vertical axis is the relative brightness (that is, the optical transmittance of the liquid crystals). If the image voltage (V_1 or V_m, for example) is not gamma-corrected and is applied as is,

a favorable image cannot be displayed due to conformity with the nonlinear correlation. Hence, in order to display a favorable image, a corrected image voltage (VI_1 or VI_m, for example), which is obtained by gamma-correcting the image voltage (V_1 or V_m, for example) in order to follow the broken straight line B which represents a linear correlation between the image voltage and the brightness, is taken as the applied voltage.

[0003] A gamma correction circuit that performs gamma correction in a liquid crystal display device in this manner, as disclosed in Japanese Patent Application Laid Open No. H10-108040 (Patent Document 1), Japanese Patent Application Laid Open No. H11-32237 (Patent Document 2), or U.S. Patent No. 5,796,384 (Patent Document 3), for example, is known. Further, the present applicant proposed, in Japanese Application No. 2002-326266 (Japanese Patent Application Laid Open No. 2004-165749) (Patent Document 4), a gamma correction circuit for which the gamma correction circuits disclosed in Patent Documents 1, 2, and 3 represent the prior art. Fig. 6 shows a liquid crystal display device that has the same gamma correction circuit as that of Patent Document 4. The liquid crystal display device 101 has a gamma correction circuit 105a that outputs gamma-corrected set voltages VI_1 and VI_m; a source driver 6 to which image data Di of n bits (eight bits, for example) are input and which, by selecting a corresponding gamma-corrected set voltage of VI_1 to VI_m or a corresponding interpolation voltage thereof (subsequently described), outputs a

corrected image voltage V_o as an applied voltage to each of the source lines in a display panel 107 (subsequently described); the display panel 107; a gate driver 8 that drives the gate lines of the display panel 107; and a nonvolatile memory 109 that saves gamma correction data.

[0004] The gamma correction circuit 105a includes a gamma correction data output circuit 111a that converts serial gamma correction data that are input from the outside via an input terminal SD into L-bit (10-bit, for example) parallel gamma correction data which are digital data corresponding to the gamma-corrected set voltages VI_1 to VI_m and outputs such data; m (nine, for example) registers 12_1 to 12_m that input and hold the parallel gamma correction data; 10-bit D/A converters (DAC) 13_1 to 13_m, for example, which convert data output by the registers 12_1 to 12_m into analog voltages; buffers 14_1 to 14_m to which the analog voltages output by the D/A converters (DAC) 13_1 to 13_m are input and which output the gamma-corrected set voltages VI_1 to VI_m by raising the current capacity. The gamma correction data output circuit 111a saves gamma correction data in the nonvolatile memory 109 and retrieves the data from the nonvolatile memory 109 when required.

[0005] The source driver 6 includes a resistance ladder 15 that generates interpolation voltages by interpolating uniformly with m' resistances between adjacent voltages of the gamma-corrected set voltages VI_1 to VI_m (between VI_1 and VI_2, for example) which are the outputs of the gamma correction circuit 105a; a decoder 16 that outputs the corrected image voltage Vo by selecting a gamma-corrected set

voltage of VI_1 to VI_m or an interpolation voltage in accordance with the n-bit image data Di. The display panel 107 to which the corrected image voltage Vo is input has 2^n grayscales. That is, supposing n is 8, the display panel 107 has 256 grayscales. The value of m' is found by $2^n/(m-1)$. That is, supposing that n is 8 and m is 9, m' is 32. For example, if the value of the image data Di is 0, the corrected image voltage Vo is a voltage equal to VI_1 and, if the value of the image data Di is 16, the corrected image voltage Vo is the center voltage of VI_1 and VI_2.

[0006] During an adjustment, the display of the display panel 107 is confirmed in real time and, by inputting serial gamma correction data to the gamma correction circuit 105a via the input terminal SD from the outside, the gamma-corrected set voltages VI_1 to VI_m are adjusted to the appropriate values. Once the adjustment is complete, the adjusted gamma correction data are saved in the nonvolatile memory 109 and gamma correction data saved in the nonvolatile memory 109 are subsequently used.

[0007] A liquid crystal display device which has the same elements as another embodiment of Patent Document 4 is shown in Fig. 7. A liquid crystal display device 102 has a source driver 6, a display panel 107, a gate driver 8 and a nonvolatile memory 109, each of which has substantially the same circuit configuration or the same structure as the liquid crystal display device 101. The liquid crystal display device 102 also has a gamma correction circuit 105b that has a different

configuration from the gamma correction circuit 105a. The gamma correction circuit 105b includes a gamma correction data output circuit 111b, two sets of m registers 12_1a to 12_ma and 12_1b to 12_mb that hold data corresponding with the odd number turn/even number turn among horizontal lines (scan lines in a horizontal direction) of the display panel 107, selectors 117_1 to 117_m that switch and select the sets of registers and output data to D/A converters 13_1 to 13_m (subsequently described), a selector control circuit 118 to which a horizontal synchronization signal HS which is a synchronization signal for the horizontal lines of the display panel 107 is input and which performs switching control of selectors 117_1 to 117_m in accordance with the odd number turn/even number turn among the horizontal lines, D/A converters 13_1 to 13_m, and buffers 14_1 to 14_m. In addition to the functions of the gamma correction circuit 105a, the gamma correction circuit 105b is able to rapidly change the gamma-corrected set voltages VI_1 to VI_m in accordance with the odd number turn/even number turn among the horizontal lines and is therefore suited to the driving method of a line inversion system that inverts a positive or negative polarity between the adjacent upper and lower horizontal lines in the display panel 107, for example.

[0008] A liquid crystal display device that has the same elements as the other embodiment of Patent Document 4 is shown in Fig. 8. A liquid crystal display device 103 has the source driver 6, display panel 107, gate driver 8, and nonvolatile memory 109, each of which

has substantially the same circuit configuration or the same structure as the liquid crystal display devices 101 or 102. The liquid crystal display device 103 also has a gamma correction circuit 105c with a different configuration in from the gamma correction circuits 105a or 105b. The gamma correction circuit 105c includes a gamma correction data output circuit 111b, two sets of m registers 12_1a to 12_ma and 12_1b to 12_mb which save data corresponding with the odd number turn/even number turn among the horizontal lines, two sets of m D/A converters 13_1a to 13_ma and 13_1b to 13_mb which are directly connected to the two sets of m registers 12_1a to 12_ma and 12_1b to 12_mb, selectors 117_1 to 117_m which switch and select the sets and output analog voltages to the buffers 14_1 to 14_m (subsequently described), a selector control circuit 118 that performs switching control of the selectors 117_1 to 117_m in accordance with the horizontal synchronization signal HS, and buffers 14_1 to 14_m. Similarly to the gamma correction circuit 105b, the gamma correction circuit 105c is suited to the driving method of a line inversion system that inverts a positive and negative polarity between the adjacent upper and lower horizontal lines in the display panel 107, for example. However, because the gamma-corrected set voltages VI_1 to VI_m can be rapidly changed in accordance with the odd number turn/even number turn among the horizontal lines, the gamma correction circuit 105c is more suitable for systems where the frequencies of the horizontal lines of the display panel 107 are high.

[0009] Thus, an appropriate gamma correction is performed in the

liquid crystal display devices 101, 102, or 103 by adjusting the gamma-corrected set voltages VI_1 to VI_m to match each display panel 107.

[0010] In recent years, a color liquid crystal display device has become widespread and a further increase in screen size and higher quality display is required. As shown in Fig. 9A, the display panel of a color liquid crystal display device has a plurality of display elements arranged in two dimensions for the colors of RGB and arranged in the form of stripes in the order, R(red), G(green) and B(blue), in the column direction. Fig. 9B is a circuit diagram that corresponds to the arrangement diagram of Fig. 9A. The display elements of one row are connected to one gate line Gi (or Gi_{+1} or the like) and provided in the order, R, G, and then B. The display elements of one column are connected to one source line Sj (or Sj_{+1} or the like) for one color of RGB.

[0011] For a preferred image display, the brightness balance for the colors of RGB (that is, the color balance) must be taken in order for there to be no shift to a specified color. However, when there is a breakdown in the color balance as a result of a shift in the characteristics of the backlight or color filter when the display panel is fabricated, a phenomenon whereby the whole image contains a blue shine, for example, by shifting slightly to a specified color arises. The present inventor also considered advances in increasing the screen size of displays and, in order to attempt to further increase the quality

of the image, the present inventor focused on studying various devices and methods for making it relatively simple to adjust the white balance of the display panel that minimizes the above-described phenomenon and also focused on improving the gamma correction circuit and the display panel.

SUMMARY OF THE INVENTION

[0012] In order to overcome the problems described above, preferred embodiments of the present invention provide a gamma correction circuit and a display panel that allow the color balance of the display panel to be adjusted, as well as a display device that includes the gamma correction circuit and display panel.

[0013] The gamma correction circuit according to a preferred embodiment of the present invention is a gamma correction circuit which outputs a gamma-corrected set voltage in order to correct an image voltage in accordance with a nonlinear correlation between an applied voltage and a brightness of a display element, including a gamma correction data output circuit which outputs a plurality of gamma correction data for each color of RGB; a plurality of registers which input and hold the plurality of gamma correction data; and a plurality of D/A converters each of which converts the data of each of the plurality of registers into an analog voltage and outputs a gamma-corrected set voltage.

[0014] The gamma correction data output circuit of the gamma

correction circuit preferably outputs a plurality of gamma correction data that are input from outside for each color of RGB during an adjustment of the gamma-corrected set voltage, and fetches a plurality of gamma correction data for each color of RGB from a nonvolatile memory after the adjustment of the gamma-corrected set voltage, and outputs the plurality of gamma correction data.

[0015] The gamma correction data output circuit of the gamma correction circuit preferably outputs a plurality of gamma correction data for each color of RGB in turn in accordance with a horizontal synchronization signal of the display panel. The plurality of registers of the gamma correction circuit are preferably provided for each color of RGB, and the data of the plurality of registers of each color are selected in turn in accordance with a horizontal synchronization signal of a display panel and input to the D/A converters. Alternatively, the plurality of registers and plurality of D/A converters of the gamma correction circuit are preferably provided for each color of RGB and gamma-corrected set voltages of each color are selected in turn in accordance with a horizontal synchronization signal of the display panel and output therefrom.

[0016] The display panel according to another preferred embodiment of the present invention is a display panel in which a plurality of display elements are arranged in two dimensions for the colors of RGB and voltages of source lines are applied to a plurality of display elements connected to a selected gate line, wherein a plurality of

display elements for one color are connected to each gate line, and each gate line to which pluralities of display elements for each color are connected is selected in turn in accordance with a horizontal synchronization signal.

[0017] The display device according to yet another preferred embodiment of the present invention is a display device including the gamma correction circuit according to one of the preferred embodiments of the present invention above; a source driver to which image data are input and which outputs corrected image voltages by selecting the corresponding gamma-corrected set voltages or interpolation voltages thereof; and the display panel according to another preferred embodiment of the present invention above in which the gate lines are driven by a gate driver and the corrected image voltages of the source driver are input to the source lines.

[0018] According to preferred embodiments of the present invention, the gamma correction circuit includes a gamma correction data output circuit that outputs a plurality of gamma correction data for each color of RGB and is therefore able to perform gamma correction for each color of RGB as a result of being used in conjunction with a display panel in which a plurality of display elements for one color are connected to one gate line. As a result, the color balance of the display panel can be adjusted. Further, the display panel has a plurality of display elements for one color connected to each gate line so that a gate line to which a plurality of display elements of each color are connected

is selected in turn in accordance with a horizontal synchronization signal. Hence, the color balance can be adjusted by gamma-correcting each color of RGB by the gamma correction circuit. A display device having the gamma correction circuit and the display panel is capable of a favorable image display in which there is no shift toward a specified color.

[0019] Other features, elements, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Fig. 1 is a circuit diagram of the display device according to a preferred embodiment of the present invention.

[0021] Fig. 2 shows the display panel of the display device, wherein Fig. 2A is an arrangement diagram for the RGB display elements and Fig. 2B is the corresponding circuit diagram.

[0022] Fig. 3 is a circuit diagram of a display device according to another preferred embodiment of the present invention.

[0023] Fig. 4 is a circuit diagram of a display device according to yet another preferred embodiment of the present invention.

[0024] Fig. 5 shows a general gamma characteristic.

[0025] Fig. 6 is a circuit diagram of a display device of the prior art.

[0026] Fig. 7 is a circuit diagram of another display device of the prior art.

[0027] Fig. 8 is a circuit diagram of yet another display device of the prior art.

[0028] Fig. 9 shows a color display panel of the prior art, wherein Fig. 9A is an arrangement diagram of RGB display elements and Fig. 9B is the corresponding circuit diagram.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0029] The preferred embodiments of the present invention will be described hereinbelow with reference to the drawings. Fig. 1 is a circuit diagram of a liquid crystal display device 1 according to a preferred embodiment of the present invention. The liquid crystal display device 1 has a gamma correction circuit 5a which outputs gamma-corrected set voltages VI_1 to VI_m for correcting an image voltage in accordance with the nonlinear correlation between an applied voltage and a brightness of a liquid crystal display element, a source driver 6 to which image data Di of n bits (eight bits, for example) are input and which outputs a corrected image voltage Vo to each source line in a display panel 7 (subsequently described) as the applied voltage by selecting a corresponding gamma-corrected set voltage of VI_1 to VI_m or a corresponding interpolation voltage thereof, a display panel 7 including color liquid crystal display elements, a gate driver 8 that drives the gate lines of the display panel 7, and a nonvolatile

memory 9 that saves gamma correction data. Here, the source driver 6 and the gate driver 8 may preferably have substantially the same circuit configuration as that of the liquid crystal display device 101 mentioned above.

[0030] The gamma correction circuit 5a includes a gamma correction data output circuit 11a that converts serial gamma correction data that are input sequentially for each color of RGB from the outside via an input terminal SD into L-bit (10-bit, for example) parallel gamma correction data which are digital data corresponding to a gamma-corrected set voltage of VI_1 to VI_m and outputs such data; m (nine, for example) registers 12_1 to 12_m that input and hold the parallel gamma correction data; 10-bit D/A converters (DAC) 13_1 to 13_m, for example, each of which converts data output by each of the registers 12_1 to 12_m into an analog voltage; and buffers 14_1 to 14_m to which the analog voltages output by the D/A converters (DAC) 13_1 to 13_m are input and which output the gamma-corrected set voltages VI_1 to VI_m by raising the current capacity. The gamma correction data output circuit 11a converts serial gamma correction data that are sequentially input for each color of RGB from the outside via the input terminal SD during the adjustment of the gamma-corrected set voltages VI_1 to VI_m into parallel gamma correction data, outputs the parallel gamma correction data to the registers 12_1 to 12_m and saves the gamma correction data for each color of RGB (that is, R gamma correction data, G gamma correction data, and B gamma correction data) in the nonvolatile memory

9. The gamma correction data output circuit 11a retrieves gamma correction data saved in the nonvolatile memory 9 for each color of RGB in turn in accordance with the horizontal synchronization signal HS of the display panel 7 after adjusting the gamma-corrected set voltages VI_1 to VI_m and outputs the gamma correction data to the registers 12_1 to 12_m.

[0031] The display panel 7 has a plurality of display elements arranged in two dimensions for the colors of RGB as shown in Fig. 2A and arranged in the form of stripes in the order, R(red), G(green) and B(blue) in the row direction. Fig. 2B is a circuit diagram that corresponds with the arrangement diagram of Fig. 2A. A plurality of display elements for one color of RGB are connected to each one row, that is, each gate line Gi (or Gi_{+1} or the like). A plurality of display elements are connected in the order, R, G, and then B to each column, that is, one source line Sj (or Sj_{+1} or the like). In the display panel 7, a gate line Gi (or Gi_{+1} or the like) to which a plurality of display elements of each color are connected is selected by the gate driver 8 in turn in accordance with the horizontal synchronization signal HS and a voltage of the source line Sj (or Sj_{+1} or the like) is applied to each of the plurality of display elements connected to the selected gate line Gi (or Gi_{+1} or the like).

[0032] The operation on and after the adjustment of the gamma-corrected set voltages VI_1 to VI_m will be described next. First, a description for the operation on the adjustment of the gamma-corrected

set voltages VI_1 to VI_m will be provided. For example, when a plurality of R gamma correction data are input to the gamma correction circuit 5a in sync with the horizontal synchronization signal HS, R gamma-corrected set voltages VI_1 to VI_m that correspond with the gamma correction data are output. An image voltage Vo for the color R corrected by the gamma-corrected set voltages VI_1 to VI_m is output from the source driver 6 to the display panel 7 as an applied voltage. A unique characteristic is that a gate line to which the R display elements in the display panel 7 are connected will be selected. That is, R image voltages that have been corrected by the R gamma-corrected set voltages VI_1 to VI_m that correspond with the R gamma correction data input to the gamma correction circuit 5a are applied to the R display elements. A plurality of G gamma correction data are then input to the gamma correction circuit 5a in sync with the next horizontal synchronization signal HS. G image voltages that have been corrected by the corresponding G gamma-corrected set voltages VI_1 to VI_m are applied to the G display elements. The same operation is carried out for the color B and this operation is repeated for the colors of RGB. As described above, a gamma correction is performed for each color of RGB and gamma correction data values from the outside are changed while checking the display of the display panel 7 in real time and the gamma-corrected set voltages VI_1 to VI_m are adjusted to appropriate voltages.

[0033] Once the adjustment is completed, the adjusted gamma

correction data are saved in the nonvolatile memory 9 and, subsequently, the gamma correction data saved in the nonvolatile memory 9 are used. The gamma correction data saved in the nonvolatile memory 9 correspond with the gamma characteristics of each color of RGB. Saving the gamma correction data in the nonvolatile memory 9 may be performed each time new gamma correction data are input from the outside rather than only when the adjustment is complete.

[0034] The gamma correction data saved in the nonvolatile memory 9 are used after the gamma-corrected set voltages VI_1 to VI_m have been adjusted for each color of RGB. However, in this case, the retrieving of the gamma correction data saved in the nonvolatile memory 9 is performed for each color of RGB in turn in accordance with the horizontal synchronization signal HS. Thereafter, when R gamma correction data are retrieved upon receipt of the horizontal synchronization signal HS, for example, the data are output to the registers 12_1 to 12_m, converted into analog voltages by the D/A converters 13_1 to 13_m, and output as R gamma-corrected set voltages VI_1 to VI_m via the buffers 14_1 to 14_m. R image voltage Vo that has been corrected by the gamma-corrected set voltages VI_1 to VI_m are output from the source driver 6 to the display panel 7 as the applied voltages, whereupon, as is the case during the abovementioned adjustment, one gate line to which the R display elements are connected in the display panel 7 are selected. The same operation is also performed for G and B and these operations are repeated for the colors of RGB. That is, the gamma correction circuit 5a outputs

gamma-corrected set voltages VI_1 to VI_m for each color of RGB in turn in accordance with the horizontal synchronization signal HS and one gate line of the display panel 7 to which the display elements for the associated color are connected is selected. As mentioned earlier, gamma correction is suitably performed for each color of RGB.

[0035] Thus, the gamma correction circuit 5a is able to perform gamma correction on each color of RGB and, accordingly, adjust the white balance of the display panel. The display panel 7 has a plurality of display elements connected to gate lines so that one gate line to which a plurality of display elements for one color are connected is selected in turn in accordance with the horizontal synchronization signal HS. Therefore, by performing gamma correction on each color of RGB by the gamma correction circuit 5a, the white balance can be adjusted. The liquid crystal display device 1 that has the gamma correction circuit 5a and the display panel 7 is capable of a favorable image display without a shift to a specified color.

[0036] A liquid crystal display device 2 of another preferred embodiment of the present invention will be described next on the basis of Fig. 3. The liquid crystal display device 2 represents an improvement of the liquid crystal display device 1 from the perspective of minimizing the current consumption. The liquid crystal display device 2 preferably includes a source driver 6, a display panel 7, a gate driver 8, and a nonvolatile memory 9, each of which preferably has substantially the same circuit configuration or the same structure

as that of the liquid crystal display device 1. The liquid crystal display device 2 also has a gamma correction circuit 5b which has a different configuration from the gamma correction circuit 5a. The gamma correction circuit 5b includes a gamma correction data output circuit 11b, three sets of m registers 12_1R to 12_mR, 12_1G to 12_mG, and 12_1B to 12_mB which are provided for each color of RGB, selectors 17_1 to 17_m which switch and select any of these sets of registers and output data to the D/A converters 13_1 to 13_m (subsequently described), a selector control circuit 18 that performs switching control of the selectors 17_1 to 17_m in turn in accordance with the horizontal synchronization signal HS, D/A converters 13_1 to 13_m, and buffers 14_1 to 14_m.

[0037] The gamma correction circuit 5b retrieves all the gamma correction data for the colors of RGB from the nonvolatile memory 9 when the power is turned ON and causes the three sets of registers 12_1R to 12_mR, 12_1G to 12_mG and 12_1B to 12_mB to hold the gamma correction data. The data held for each color of RGB are selected in turn in accordance with the horizontal synchronization signal HS and input to the D/A converters 13_1 to 13_m, converted into analog voltages, and then output as gamma-corrected set voltages VI_1 to VI_m via the buffers 14_1 to 14_m. Thus, although the liquid crystal display device 1 retrieves gamma correction data saved in the nonvolatile memory 9, that is, accesses the nonvolatile memory 9 for each horizontal synchronization signal HS, the liquid crystal display device 2 is able to minimize

current consumption because the access is made to the nonvolatile memory 9 only when the power is turned on and the number of times access is made is markedly reduced.

[0038] A liquid crystal display device 3, which is yet another preferred embodiment of the present invention, will be described next with reference to Fig. 4. The liquid crystal display device 3 preferably includes a source driver 6, a display panel 7, a gate driver 8, and a nonvolatile memory 9, each of which preferably has substantially the same circuit configuration or the same structure as that of the liquid crystal display devices 1 or 2. The liquid crystal display device 3 also has a gamma correction circuit 5c which has a different configuration from the gamma correction circuits 5a or 5b. The gamma correction circuit 5c includes a gamma correction data output circuit 11b, three sets of m registers 12_1R to 12_mR, 12_1G to 12_mG, and 12_1B to 12_mB which are provided for the colors of RGB, three sets of m D/A converters 13_1R to 13_mR, 13_1G to 13_mG, and 13_1B to 13_mB which are directly connected to the three sets of m registers 12_1R to 12_mR, 12_1G to 12_mG, and 12_1B to 12_mB, selectors 17_1 to 17_m which switch and select any of these sets and output analog voltages to the buffers 14_1 to 14_m (subsequently described), a selector control circuit 18 that performs switching control of the selectors 17_1 to 17_m in turn in accordance with the horizontal synchronization signal HS, and buffers 14_1 to 14_m.

[0039] The gamma correction circuit 5c retrieves all the gamma correction data for the colors of RBG from the nonvolatile memory 9

when the power is turned ON, and then causes the three sets of registers 12_1R to 12_mR, 12_1G to 12_mG, and 12_1B to 12_mB to hold the gamma correction data and causes the D/A converters 13_1R to 13_mR, 13_1G to 13_mG, 13_1B to 13_mB to convert the gamma correction data into analog voltages for the colors of RGB. The analog voltages for each color of RGB are selected in turn in accordance with the horizontal synchronization signal HS, input to the buffers 14_1 to 14_m and then output as gamma-corrected set voltages VI_1 to VI_m. Therefore, the gamma correction circuit 5c is able to minimize the current consumption of the liquid crystal display device 3 and, because the data for the colors of RGB have already been converted into analog voltages, rapidly switch the gamma-corrected set voltages VI_1 to VI_m. Hence, the gamma correction circuit 5c is suitable for a display device that requires high-speed processing in which the frequency of the horizontal lines of the display panel 7 is high.

[0040] If the current output capacity of the D/A converter (DAC) is sufficient, buffers 14_1 to 14_m can also be omitted from the gamma correction circuits 5a, 5b, or 5c above.

[0041] Moreover, the present invention is not limited to the various preferred embodiments described above. A variety of design modifications within the scope of the items appearing in the claims are possible. For example, although a liquid crystal display device is described in the preferred embodiments, the gamma correction circuit, display panel, and display device of the present invention are not

limited to a liquid crystal display device and can be applied to display devices (an organic EL display device, for example) requiring gamma correction.

[0042] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.